1933

The Missouri Valley Traverse in Iowa North of the Jones Point Deformation

G. E. Condra
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NEBRASKA GEOLOGICAL SURVEY

Paper Number 2

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THE MISSOURI VALLEY TRAVERSE IN IOWA, NORTH OF THE JONES POINT DEFORMATION

By G. E. Condra

This paper is based on a study of the Pennsylvanian outcrops in the bluff lands of the Missouri, in a traverse between 2½ miles north of Thurman and about 5½ miles north of Council Bluffs. Its purpose is two-fold: First, to revise the nomenclature and correlation of the Pennsylvanian in this occurrence, and, second, to establish a close classification of the strata for use in the study of sedimentation, stratigraphic paleontology and economic geology.

The traverse has been described, in whole or in part, by White,[1] Todd,[2] Udden,[3-4] Smith,[5] Condra & Bengtson,[6] Tilton [7] and Condra.[8]

Nomenclature Revised.—The following corrections and additions to the nomenclature are embodied in this report:

1. The "Meadow limestone," as it has been applied in this traverse, is the Sheldon limestone.
2. Moore & Condra group the Sheldon limestone and Jones Point shale with the Deer Creek formation and thus reduce the Calhoun to the sediments between the Sheldon limestone and the Topeka formation. This eliminates the term "Iowa Point shale."
3. The "Haynies limestone" member of the Deer Creek, according to Condra & Moore, is the Plummer limestone of Oklahoma.

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[1] White, C. A., Iowa Geol. Surv., Vol. I, 1870, pp. 358–395.

[2] Todd, J. E., On the Folding of the Carboniferous Strata in Southwestern Iowa; Proc. Iowa Acad. Sci., Vol. 1, part 1, 1889; also, Some Variant Conclusions in Iowa Geology; Idem, Vol. 13, 1906, p. 612.

[3] Udden, J. A., Geology of Pottawattomie County, Iowa; Iowa Geol. Surv., Vol. XI, 1900, pp. 201–277.

[4] Udden, J. A., Geology of Mills & Fremont counties; Iowa Geol. Surv. Vol. XIII, 1903, pp. 137–149.

[5] Smith, Geo. L., The Carboniferous Section of Southwestern Iowa, Iowa Geol. Surv., Vol. XIX, 1908, pp. 647–649.

[6] Condra, G. E. & Bengtson, N. A., The Pennsylvanian Formations of Southeastern Nebraska; Nebr. Acad. Sci., Vol. IX, No. 2, 1915.

[7] Tilton, J. L., The Missouri Series of the Pennslyvanian System in Southwestern Iowa; Iowa Geol. Surv., Vol. XXIX, 1920, pp. 252–253.

[8] Condra, G. E., Stratigraphy of the Pennsylvanian System in Nebraska; Nebr. Geol. Surv., Vol. 1, Second Series, 1927, pp. 127-130.

4. The "Cullom limestone" is the Beil limestone.
5. Condra has separated the Tecumseh formation into three members and named them the Rakes Creek shale, Ost limestone and the Kenosha shale. These members now recognized in Nebraska, are to be applied in the Iowa traverse.

Correlation: The formations exposed in the lower course of the Platte Valley of Nebraska are much older than is shown by the early geological surveys. The age and correlation of these beds, recently revised, has a bearing on the classification of the sections near Crescent and Council Bluffs, Iowa. The correlation of the beds in the southern part of the Iowa traverse is to be made with type localities in Nebraska, located in the Weeping Water and Missouri River valleys.

Acknowledgments.—The writer is indebted to C. E. Busby for drafting the figures in this report, and to George Dunn for typing the manuscript.

The Iowa traverse includes five widely spaced sections, which are now described in order from south to north.

THE WILSON SECTION

(See Columnar Section No. 1)

This, the Wilson section by White, is located north of Thurman (2 to 4 miles), southeast of Bartlett (2 to 3½ miles) and southwest of Tabor (4 to 6 miles). It is in Mills County, in T. 70 N., R. 43 W., extending from the SW of Section 23 northward and northeastward into Section 14. The location is on the north flank of the Jones Point deformation, the anticlinal part of which has been described as the Redfield anticline. The beds dip northward about 50 feet or more within the area considered, passing into the Bartlett syncline.

Most of the detailed measurements for the section were made at a quarry which was opened in Section 14 in 1932, and at natural exposures, one in the north branch of Indian Creek at a point about ½ mile east of the river bluffs, and the other about 4/10 mile north of where this creek emerges from the bluffs.

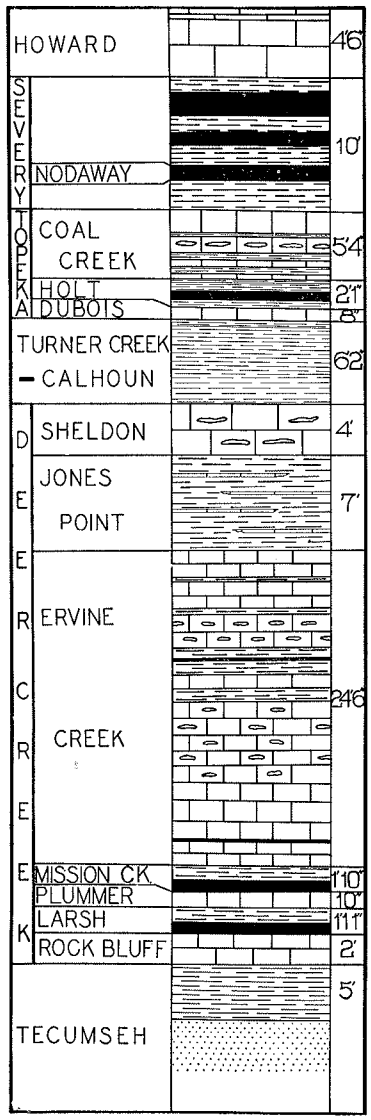

Figure 1.—Columnar Section No. 1

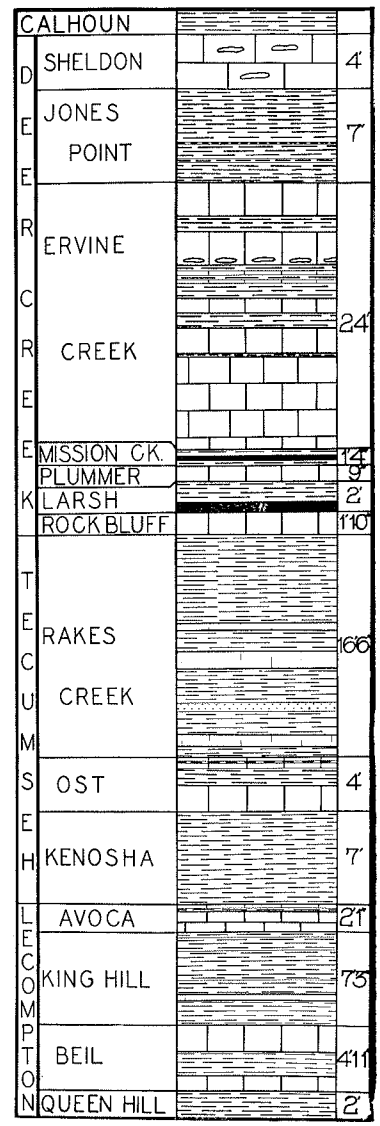

Figure 2.—Columnar Section No. 2

The beds of this section are better exposed now (1933) than before, due to the opening of a new quarry about ¼ mile south of where Indian Creek passes onto the Missouri River bottomland. The strata uncovered in this quarry represent the complete sequence of strata from the Coal Creek limestone down to the base of the Ervine Creek limestone. Also, the horizons above the Coal Creek are quite well shown in the Indian Creek Valley and in the bluffs of the Missouri about 4/10 mile north of where Indian Creek passes onto the bottomland of the Missouri. The composite section:

1. Howard limestone (exposed in the north branch of Indian Creek about ½ mile east of the river valley), gray, in thin layers at top and more massive in lower part, weathered yellowish, about 4′ 6″.
2. Severy shale (Indian Creek Valley), about 10′:
   (1) Shale, yellowish, calcareous, 1′.
   (2) Shale, black, bedded, 1′ 10″.
   (3) Shale, olive colored, argillaceous, with *Ambocoelia*, etc., 1′ 2″.
   (4) Shale, black, bedded, 1′.
   (5) Shale, olive colored, calcareous, with *Ambocoelia, Chonetes*, etc., 1′ 6″.
   (6) Nodaway coal, 1′+.
   (7) Shale, bluish-gray, quite fossiliferous, 2′.
3. Topeka formation (in bluffs 4/10 mile north of the mouth of Indian Creek), 8′+.
   (1) Coal Creek limestone, 5′ 4″:
      a. Limestone, bluish-gray, massive, fine-grained, fossiliferous, forms large blocks, 1′ 9″.
      b. Shale parting.
      c. Limestone, bluish-gray, dense, weathers nodular and irregular, contains much dark chert, 1′ 5″. The top of this limestone contains many *Polypora* and *Rhombopora* and the base is quite crinoidal.
      d. Shale, olive to buff, *Ambocoelia* very common, 5″.
      e. Limestone, bluish-gray, dense, to fine-grained, contains *Marginifera*, upper surface contains many *Ambocoelia* and productids, 7″.
      f. Shale, olive to bluff, contains many *Ambocoelia*, 6″.
      g. Limestone, bluish-gray, argillaceous, dense, contains many *Marginifera*, upper surface transitional to shale and filled with *Ambocoelia*, 6″-8″.
   (2) Holt shale (high in new quarry), 2′ 1″:
      a. Shale, bluish-gray to dark, 2″.
      b. Shale, olive, massive, very fossiliferous, with *Ambocoelia planoconvexa, Hustedia, Derbya, Aviculopecten*, etc., 10″.
      c. Shale, black fissile, 8″.
      d. Shale, bluish-gray to olive, with *Aviculopecten, Ambocoelia*, etc., 5″.
   (3) DuBois limestone (in new quarry), bluish-gray, massive to dense, argillaceous, very fossiliferous, contains *Bellerophons*, productids, *Chonetes*, etc., 7″-8″. This limestone occure in two

beds, the upper being persistent and the lower lenticular; both beds are somewhat granular and coquina-like in places.

4. Topeka-Calhoun (in new quarry), about 6′ 2″:
   (1) Shale, yellowish-brown, very limy, nodular, contains *Derbya, Aviculopecten, Ambocoelia,* etc., 6″.
   (2) Shale, bluish-gray, massive, limy, nodular, about 6′; basal 1′ to 1′ 6″ buff, very limy, grading into limestone.
5. Deer Creek formation (in new quarry), about 42′:
   (1) Sheldon limestone, light gray, massive, pseudo-oolitic, somewhat granular, forms large blocks, contains osagea, *Bellerophons,* bryozoa, etc., 3′ 8″-4′. This member drops to the level of the bottomland about 4/10 mile north of the mouth of Indian Creek.
   (2) Jones Point shale, greenish to buff, massive, blocky, has four or five seams of fossiliferous limestone, contains many *Chonetes granulifer, Marginiferas, Derbyas* and fenestrated bryozoa, 7′.
   (3) Ervine Creek limestone, about 24′ 6″:
      a. Limestone, brownish-gray, granular, massive, contains Bellerophontid gastropods, etc., 2′-2′ 4″.
      b. Shale, bluish-gray, massive, 1″-4″.
      c. Limestone, light gray, argillaceous, chalky to finely granular, weathers buff, with large *Myalina* on upper surface, 2′-2′ 2″.
      d. Shale, bluish-gray, massive, about 5″.
      e. Limestone, gray to light brownish, massive, contains dark chert, 2′ 4″-2′ 6″.
      f. Shale, 2′ 2″:
         (a) Shale, olive-colored, calcareous, part indurated, crinoidal, 10″-1′.
         (b) Shale, black, massive, 1″-3″.
         (c) Shale, bluish-gray to olive, dark at top and in places at bottom, fossiliferous, 1′-1′ 2″.
      g. Limestone, gray to bluish-gray, dense, buhr-stone-like in texture, with considerable algal material, 1′ 1″.
      h. Shale, greenish to dark, weathers crumbly, 1′.
      i. Limestone, gray, fine-grained, massive, 2′ 6″.
      j. Limestone, dark gray, bottom and top shaly, 2′ 3″.
      k. Limestone, light gray, massive, weathered brownish, contains much nodular dark chert, and has a dark gray seam (1″-2″) above middle and another (1″ thick) about 1′ 2″ above base. The shaly seams are filled with *Triticites;* total thickness, 6′.
      l. Shale, black, 1″-2″.
      m. Limestone, dark gray, massive, earthy, nodular, surface, of vertical face very uneven, weathered dark gray, 2′; contains osagea, *Triticites, Amblysiphonella prosseri, Lophophyllum, Fistulipora,* etc.
   (4) Mission Creek shale (at foot of bluff, north end new quarry), bluish-gray to olive and black, argillaceous, 1′ 10″.
   (5) Plummer ("Haynies") limestone, badly covered, bluish-gray, about 10″.
   (6) Larsh shale (exposed by excavation at new quarry), bluish-gray to black and fissile, 1′ 11″.
   (7) Rock Bluff limestone (excavation at new quarry), dark gray, dense, blocky, 1′ 10″-2′. Altitude of the base of this member at new quarry, about 952′.
6. Tecumseh shale, now covered, exposed in 1870 and measured by White as follows:
   (1) Shale, bluish, argillaceous, 4′.
   (2) Sandstone, micaceous, fine-grained, 1′.

Discussion: Dr. White's (1) description of the foregoing section is very accurate. It shows all of the natural subdivisions as they are now known. Geologists later than White have re-measured the beds and made gradual progress in correlating them with the type localities in Missouri, Kansas and Nebraska.

The late Professor Todd (2) was first to call the attention of geologists to the deformation north of Thurman and explain the relation the younger beds exposed south of it hold to the older beds exposed north of it. Dr. Smith (5) describes the deformation under the name, Thurman-Wilson fault. The late Professor Tilton (7) maps the fault northeastward to Adair County, and recognizes the fold north of it, near Thurman, as the Redfield anticline. Condra & Bengtson (6) name the structure (fault and fold) the Jones Point deformation, and a year later Keyes calls it the Red Oak fault.

Dr. George L. Smith, deceased, did most in the classification of the Pennsylvanian in southwestern Iowa. Second to him, in this work, was Professor Tilton, also deceased.

All members of the Topeka formation extend from Kansas into southeastern Nebraska, but the Curzen limestone plays out at Jones Point in Nebraska. Therefore, if the Turner Creek shale extends to the Wilson section, it is here in contact with the Calhoun. Consequently, the age of Division 4 of the section is classed as Topeka-Calhoun.

Bartlett Syncline.—This crosses our traverse east of Bartlett, i.e., near the Fremont-Mills county line. It is a broad trough extending NE-SW. The strata rise quite perceptibly northwestward from this syncline into the Haynies section where the altitude of the geologic units is 40 or 50 feet above that of their position in Jones Point deformation. This upbend of the strata in the Haynies section is in line with the deformation southeast of Rock Bluff, Nebraska, where the strata rise northwestward about 50 feet within a distance of about two miles.

THE HAYNIES STATION SECTION

(See Columnar Section Number 2).

This is located along the bluff-line southeast of Haynies Station (now Sargent's Siding), Mills County. It is in T. 71 N., R. 43 W., extending northward and northeastward for a distance of about 3½ miles from the SW of Section 27 to near the center of Section 10. White, Udden, Smith, Tilton and Condra have described the exposures here. (See references cited). The section:

1. Calhoun shale, basal part formerly exposed, now badly covered.
2. Deer Creek formation, about 41′:
   (1) Sheldon limestone (at top of largest abandoned quarry), bluish-gray, massive, with some chert, weathered gray or yellowish, forms large blocks, quite fossiliferous, 4′.
   (2) Jones Point shale, about 6′ 6″-7′:
      a. Shale, gray, massive, loosely indurated, 3′ 9″-4′.
      b. Limestone, light gray, uneven, fossiliferous, 2″.
      c. Shale, gray, bedded, with some thin light gray lenses and lensing lime, fossiliferous, 1′ 2″.
      d. Limestone, light gray, blocky, fossiliferous, 2″.
      e. Shale, bluish-gray, 1′-1′ 3″.

      Fauna: *Chonetes granulifer, Derbya crassa, Neospirifer triplicatus,** pelecypods, echinoid spines, *Septopora biserialis, Rhombopora lepidodendroides, Polyporas, Fenestellas*, etc. The pelecypods are mostly in the lower lime seam.
   (3) Ervine Creek limestone, about 24′:
      a. Limestone, poorly exposed, soft, impure, weathered yellowish, somewhat porous, and chalk-like, irregular, about 2′ 6″. This is (3) a, b, c, of the Wilson section.
      b. Shale, bluish, calcerous, top uneven, grading into Zone a, 1′-1′ 3″.
      c. Limestone, in two beds separated by a thin shale seam just above middle, weathered yellowish, with considerable chert in lower bed and not many fossils, 2′ 6″.
      d. Limestone and shale, 2′ 6″:
         (a) Shale, gray, calcareous, 6″.
         (b) Limestone, gray, one bed, 3″-4″.
         (c) Shale, bluish, to dark gray, argillaceous, 5″.
         (d) Limestone, gray, uneven, 3″.
         (e) Shale, about 1′; bluish-gray and argillaceous above; dark below.
      e. Limestone, dark gray, dense, with some calcite, forms angular blocks, 1′ 2″.
      f. Shale, bluish-gray, crumbly, fossiliferous, 1′ 2″.
      g. Limestone, dark gray, massive, separated by thin shale seams, 13′; upper part best shown at main abandoned quarry; middle and basal zones exposed farther south. There are *Chonetes granulifer, Fistuliporas* and *Amblysiphonellas* in the basal 2′.
   (4) Mission Creek shale (in road-side ditch in Section 27), grayish, argillaceous, with one or two dark bands, 1′ 4″ or more.

* The brochiopod names used in this paper are described in Bull. 5, Second Series, Nebraska Geological Survey.

(5) Plummer ("Haynies") limestone (road ditch in Section 27), bluish-gray, dense, massive, with a good many crinoid joints, 9".
(6) Larsh shale (in road ditch), 2'; upper part bluish, argillaceous; basal part quite dark, forms fissile debris.
(7) Rock Bluff limestone (in road ditch), bluish-gray, dense, massive, forms rectangular blocks, 1' 9"-1' 10". The altitude of the base of this member southeast of Haynies section is 1000 feet or more.

3. Tecumseh formation (exposed in ravines in the SW of Section 10, i.e., north of the largest abandoned quarry), about 27' 6":
(1) Rakes Creek shale, 16' 6":
a. Shale, largely bluish-gray, argillaceous-arenaceous, floury, about 6' 6".
b. Limestone, grayish, sandy, blocky, 6".
c. Shale, bluish-gray, arenaceous, 1' 2"-1' 6".
d. Mudstone-sandstone, yellowish, calcareous, top mammillary, irregular, 1' 2".
e. Shale, bluish-gray, argillaceous, 2' 6".
f. Sandstone, buff, 8".
g. Shale, bluish, 2'.
h. Mudstone, bluish, calcareous, weathers buff, 1'.
i. Shale, blue, argillaceous, 1'.
(2) Ost limestone, about 4':
a. Limestone, gray, dense, hard, 4'.
b. Shale, gray, 1"-2".
c. Limestone, dark gray, earthy, 6"-7".
d. Shale, bluish, 1' 2".
e. Limestone, yellowish, impure, unevenly rounded, arenaceous, 1' 9".
(3) Kenosha shale, largely bluish and argillaceous, with *Ambocoelia* at base, 7'.

4. Lecompton formation (in Section 10), about 16' 3" exposed:
(1) Avoca limestone (near level of bluff-line road and in hog lot in E ½ of Section 10), about 2' 1":
a. Limestone, bluish-gray, granular to dense, contains numerous *Cancrinella boonensis*, 3".
b. Shale, dark gray, bedded, very fossiliferous, *Ambocoelia planoconvexa* abundant, 4".
c. Limestone, bluish-gray, top very irregular, filled with large *Rhombopora*, *Polypora* and crinoid joints, has very irregular fracture and weathers bluish-gray, massive, 10".
d. Limestone, bluish-gray, nodular, argillaceous, transitional to the shale below, contains crinoid joints, *Triticites*, brachipods, etc., 8".
(2) King Hill shale (section in hog lot in E ½ of Section 10), 7' 3":
a. Shale, bluish-gray blocky, with limy pellets and nodules, 6".
b. Mudstone, olive to buff, 1' 2".
c. Shale, bluish-green, blocky, massive, 2' 7".
d. Mudstone, bluish-gray, nodular, irregular, weathers yellowish, 1'.
e. Shale, bluish-green, massive, blocky, 2'.
(3) Beil limestone (in ravine in hog lot), 4' 11":
a. Limestone, light gray, calcerous, massive, filled with osagea, contains some *Triticites*, *Compositas* and other brachiopods, base very crinoidal, 2' 6".
b. Shale, olive to buff, indurated, contains many *Campophyllum*, *Neospirifer*, crinoid joints, etc., 1' 7".

c. Limestone, light gray, fine-grained, massive, top filled with *Syringoporas, Fistulipora,* crinoid joints and *Compophyllum torquium,* 10″,

(4) Queen Hill shale, bluish-gray, massive, 2′ exposed in bed of ravine.

Note: The members of the Deer Creek are nearly identical in the preceding sections except that the top zone of the Ervine Creek appears to be less well developed in the Haynies section. The top of the Plattsmouth limestone is thought to occur above the level of the flood plain of the Missouri in the Haynies section, covered by colluvial material.

The next outcrop in our traverse is on Keg Creek, about 3½ miles north and ½ mile east from the nearest exposures of the Haynies section. The area between the Haynies section and the Keg Creek exposure is broad Missouri River bottomland bordered on the east by sloping upland without Pennsylvanian outcrops. If it has not been removed by erosion, the Plattsmouth probably extends through this area to Keg Creek and beyond, with a slow rise northwestward.

KEG CREEK EXPOSURE

This is located on Keg Creek about 1½ miles east of Pacific Junction, near what was called Mills Station. It is just south of the Burlington Railway and west of the north-south county highway. About 13′ of the middle and lower zones of the Plattsmouth has been exposed in the bed and right bank of the creek. However, the creek channel, where the outcrop occurs, was abandoned in 1932, due to the construction of a large drainage ditch, and, no doubt, the abandoned channel will soon fill with alluvial sediments and thus cover the limestone. As observed September 19, 1933, about 9′ of this section remained uncovered, its eroded top being at an altitude of about 950 feet and about 13′ 6″ below the level of the railroad located just north.

Note: The next exposures in this traverse are in the foot of the bluff at Folsom, Mills County, about 6½ miles northwest from the Keg Creek outcrop. No doubt, the Plattsmouth limestone, though covered with Pleistocene deposits, is in the foot of the bluffs between Keg Creek and the Folsom section, rising slowly northward. The structural attitude of the Plattsmouth and older beds from the Haynies section to

Folsom is thought to be about the same as it is in Nebraska from Rock Bluff to northeast of Plattsmouth, the altitude of the members being the higher in the traverse west of the river.

THE FOLSOM (HINTON STATION) SECTION

(See Columnar Section Number 3)

Location: In foot of bluffs; between ¾ mile south and ⅛ mile north of Folsom; in the W½ of Section 29, T. 73 N., R. 43 W.

This section has been described by Udden,[4] Tilton [7] and Condra. [8] Udden's section was copied by Tilton who cor-

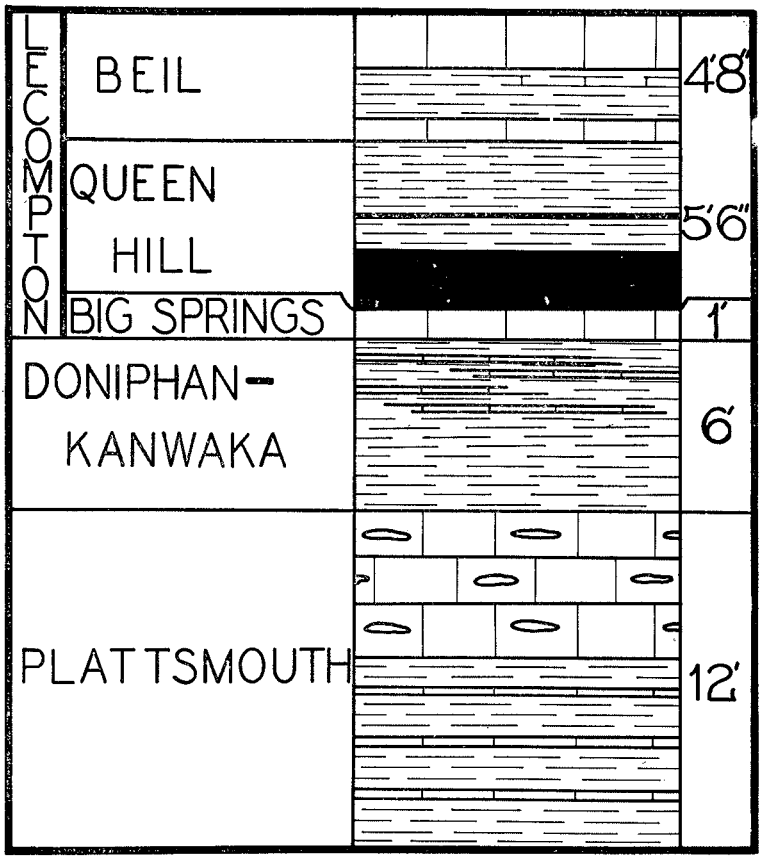

Figure 3.—Columnar Section No. 3

related the beds as follows: "In the list of fossils, the large proportion of pelecypods and crinoids is noteworthy. . . . The writer is classifying the section as a part of the Lansing stage (Stanton limestone). It is clearly below the Oread limestone, suggests the Weepingwater limestone of Nebraska and may help to fix the Weepingwater in its proper place in the geologic column as recognized in Missouri and Iowa."

Condra (8) says: "Highway excavation made below Folsom in 1926 exposed the Cullom limestone and a few feet of underlying beds which are nearly identical with those at Rock Bluff and near Nehawka. The section includes layers from a few feet above the Cullom limestone down to the base of the top zone of the Plattsmouth limestone which outcrops just northeast of the station, rising northward. Excavation made here shows that Zone B of the Plattsmouth is 7′ or 8′ thick." It should be observed that the "Cullom limestone" as used here, is the Beil limestone. Section :

1. Lecompton formation (exposed from the store at Folsom southward about ¾ mile), about 11′ 2″ shown:
   (1) Beil limestone, about 4′ 8″:
      a. Limestone, poorly exposed, gray, massive, fossiliferous, about 2′.
      b. Shale, argillaceous-calcareous, bluish-gray, weathered yellowish, with lime seams in upper part, contains *Campophyllum torquium*, brachiopods, crinoid joints, etc., about 1′ 6″-1′8″.
      c. Limestone, gray, weathered, yellowish, badly shattered, fossiliferous, with *Campophyllum*, *Syringopora*, crinoid joints, etc., about 1′.
   (2) Queen Hill shale, about 5′ 6″:
      a. Shale, gray, argillaceous, crinoid joints, brachiopods, etc., about 2′ 2″.
      b. Shale, a black seam, 1″-2″.
      c. Shale, gray, about 1′.
      d. Shale, black, fissile, about 2′ 3″.
   (3) Big Springs limestone (best shown at ravine ½ mile south of Folsom), dark gray, earthy, top 2″ slabby, with *Chonetes*, *Triticites*, crinoid joints, etc., 1′.
2. Lecompton-Plattsmouth shale, largely bluish-gray and argillaceous, with thin limestone seams in upper part filled with *Chonetes* and *Linoproductus prattenianus;* thickness about 5′-6′. The *Chonetes* are scattered in the upper part of this division and *Linoproductus* is abundant at 6 inches and 2 feet below the top of the shale.
3. Plattsmouth limestone, exposed from just east of store northward ⅛ mile where its top is 8′ above elevation of railroad at the store; thickness shown in natural outcrop and excavation, about 12′.
   (1) Stone, gray, massive, cherty, fossiliferous, weathered yellowish, 5′ or more. The altitude of the top of this at a point northeast of the store is about 970′.

(2) Shale and limy layers, in excavation made northeast of store, bluish-gray, fossiliferous, about 7'.

Discussion.—Division No. 2 of this section represents the lower Lecompton, Kanwaka and the upper Plattsmouth horizons. All of the Lecompton members occur in northeastern Kansas and southeastern Nebraska, north of which, due to the failure of the Spring Branch limestone, the Doniphan shale, if here, is in contact with the Kanwaka shale which thins out northward. Then, too, the Kereford limestone or top member of the Plattsmouth probably does not persist northward beyond the Weeping Water Valley of Nebraska, which probably brings the Kanwaka into contact with the Heumader shale member of the Plattsmouth, but in the absence of the Kanwaka, the Doniphan is in contact with the Heumader where it is present. Therefore, Division No. 2 at Folsom is classed as Lecompton-Plattsmouth in age.

The Kanwaka shale probably does not reach northward to the Folsom section and it is not certain whether the sediment in Division 2 of the section is Lecompton or Plattsmouth, or both, however, its faunal sub-zones are identical with the horizon exposed at places in the Weeping Water Valley. The massive top limestone of the Plattsmouth at Folsom also persists to the Weeping Water Valley where it is underlain by about 3½ feet of shale which thickens northeastward to about 6 feet in the Platte Valley north of the city of Plattsmouth and about 7 feet at Folsom. The main body of the Plattsmouth limestone is below this shale at these places.

The correlation of the Beil limestone in the Folsom, Haynies and Nebraska sections is definite, based on lithology, faunal content and sequence. The number is distinctive and, therefore, a good horizon marker. It has been traced through many exposures in Nebraska and northwestern Missouri and through Kansas to Oklahoma.

Note: The Plattsmouth limestone lifts northwestward in the northern part of the Folsom section, but, unfortunately, there are no outcrops of it or other Pennsylvanian beds upvalley below the site of the Mosquito Creek exposure which is 12½ miles north and ½ mile east of Folsom. There are places in this stretch of the traverse, however, where lime-

stones and shales are reported to have been encountered in shallow wells located near the bluff line.

MOSQUITO CREEK EXPOSURE

Location: East bank of Mosquito Creek, near the center of the west line of section 21, T. 75 N., R. 43 W., about 2 or 3 miles northeast of Council Bluffs. This location is about ⅜ miles northeast of Chautauqua Siding, and is reached from Council Bluffs via Highway No. 7 to a gas filling station in Mosquito Creek Valley, thence through a private road east and southeast to the railroad bridge, just east of which is where the stone was quarried.

White (1) describes the exposures on Mosquito Creek as consisting of about 7 feet of limestone with shaly partings and carrying some chert. Udden (3) mentions the outcrop and notes that limestone had been quarried there many years earlier.

White and Udden correlate the beds on Mosquito Creek with those exposed southeast of Crescent, Iowa. However, their descriptions of the outcrops do not support this correlation very strongly and it is believed that further investigation by excavation or core drilling and the collection and careful study of lithologic and faunal specimens will be required before a definite correlation can be made of the beds on Mosquito Creek.

The writer visited the site of the Mosquito Creek outcrop (1933) in company with Mr. J. H. Mayne of Council Bluffs and could not find exposures. Then, at the suggestion of Mr. Mayne, we examined two street retaining walls in Council Bluffs which contained stone quarried in Mosquito Creek Valley. This stone had been built into a foundation of an old high school from which it was later sold to the parties building the retaining walls. Apparently, this rock is not correlative in age with any part of that exposed near Crescent.

EXPOSURE NEAR CRESCENT STATION

Location: In the SE of Section 27 and the NE of Section 34, of T. 76 N., R. 44 W., Pottawattomie County, Iowa. It is in the foot of bluffland about 1½ miles southwest of Crescent

City; more specifically, the Crescent Railroad station is about 1¼ miles southwest of the town and the outcrop, such as remains, is east of the railroad and ¼ to ½ mile south of the station.

Following is Udden's (3, pp. 227, 228) section of the Crescent exposures:

5. "Limestone, yellowish and gray, in ledges from six inches to one foot in thickness, compact near the base, occasionally brecciated, and at times having a finely oolitic texture. A polished specimen of this rock is seen to consist of rounded and incrustated calcareous fragments embedded in a matrix of almost transparent crystalline calcite. The fragments are of different sizes. Some have a diameter of nearly a millimeter, and these are mingled with others of about one-fifth that diameter. Most appear elliptical in section. Some of the large fragments have a nucleus with a structure like a fragment of *Stictopora*. A few still larger fragments are pieces of small shells. This specimen also exhibits several small crooked joints or fissure veins filled with pure crystalline calcite. Another specimen appeared to the unaided eye as an ordinary compact gray limestone, but as seen, under a lens, appears to be fragmental, consisting largely of small fusulinas, some of which were surrounded by a thin calcareous crust. These, together with finer fragmental material, were embedded in a structureless calcareous matrix. Occasionally the fragments were welded together as if by partial solution and redeposition of this substance. Minute crevices and veins were abundant everywhere filled with crystalline calcite. There were also frequent plain evidences of small faulting and brecciation by fracture, 5′.
4. "Yellow shale, 2′.
3. "Yellowish-gray limestone, with occasional fusulinas, compact in texture above, but occasionally oolitic below, in some places quite soft. Contains *Allorisma subcuneata*, 2′.
2. "Blue shale, with numerous fossils and occasional crystals of selenite, The fossils observed were: *Fusulina cylindrica* (small size), *Archaeocidaris triseriata, Euphachycrinus verruscosus, Erosocrinus typus, Fistulipora nodulifera, Rhombopora lepidodendroides, Chonetes granulifer, Meekella striatacostata, Productus cora, P. costatus, P. nebrascensis, Seminuta argentia, Spirifera cameratus* (large), 5′.
1. "A sample massive ledge of fine-grained oolitic limestone, seen to contain pieces of *Chenomya, Bakevillia illinoisensis* (?), and having on its upper surface partly embedded, *Axophyllum rude, Lophophyllum proliferum, Athyris subtilita, Productus cora,* and frequent crinoid stems. In a thin section of the rock in this ledge the oolitic spherules are seen to be embedded in a transparent matrix of crystalline calcite. They average about one-fourth of a millimeter and barely fall below the limit of ready recognition to the unaided eye. The macroscopic aspect of the rock is that of an ordinary finely granular limestone. The rounded grains are usually elliptical in section and they sometimes have a crystalline transparent nucleus. In other cases the nucleus is a minute organic fragment, such as a tiny bit of fusulina or the joint of a crinoid stem. These nuclei are surrounded by an opaque crust of structureless calcite, about one-fortieth of a millimeter in thickness. Exposed, 3′." The altitude of the top of the outcrop is about 1000 feet.

Discussion: Both White (1) and Udden (3) correlate the Crescent beds with those of the Mosquito Creek exposure. Tilton (7) states that the strata at Crescent probably belong to the Plattsburg sub-stage.

That part of our traverse which extends from Folsom to Crescent is related to the Platte Valley section of Nebraska in which strata from the Sniabar ("Hertha") to the Plattsmouth are exposed in the Nehawka-Richfield anticline, which extends northeastward to Omaha and probably into Iowa. The Kansas City beds outcrop northward along the Missouri in Nebraska to Rockport (abandoned), and because of this they would be expected to occur in the vicinity of Crescent, Iowa. Apparently, therefore, the strata between north of Folsom and Crescent rise northwestward in the east flank of the Nehawka-Richfield anticline, a condition of occurrence which was not recognized by White, Udden and Tilton.

In a report published in 1927, the writer classed the Crescent beds provisionally as Plattsmouth, but, in view of later study made in the Platte Valley and along the Missouri northward to Rockport, which is across the Missouri and about five miles northwest from Crescent, he is forced to conclude that the beds at Crescent are older than the Plattsmouth and that they are either the Westerville or the Winterset. More likely, they are the Westerville which is the "Drum" limestone in the Kansas City section. This provisional correlation is further supported by the results of lithologic and faunal study of specimens collected at Crescent.

If the beds near Crescent are the Westerville, and there is no upthrow by faulting across the traverse, all of the formations in the general section from Westerville to the Plattsmouth limestone dip southeastward between Crescent and some point north of Folsom, within a distance of about 19 miles or less. These formations (in ascending order) are the Quivira shale, Cement City limestone, Chanute shale, Paola limestone, Muncie Creek shale, Raytown limestone, Argentine limestone, Island Creek shale, Farley limestone, Plattsburg limestone, Vilas shale, Stanton limestone, Weston shale, Iatan limestone, Lawrence shale and the Weepingwater,

Snyderville, Leavenworth and Heebner members of the Oread. All of the subdivisions of this interval, with a combined thickness of about 194 feet are exposed in the Platte Valley of Nebraska an most of them have been identified in the vicinity of Winterset, located in south-central Iowa. They probably extend through our traverse, except where they have been removed by erosion in the northern part of the area.

Should the beds on Mosquito Creek prove to be of the age of those at Crescent, then the strata lie nearly flat along the traverse between this station and Crescent, and practically all of the dip or faulting or both in the northern part of this traverse is between the Mosquito Creek exposure and Folsom, within a distance of about 12½ or 13 miles. However, should the beds on Mosquito Creek prove to be younger than those exposed at Crescent, the dip and faulting, if there is such, is in the stretch between Crescent and north of Folsom.

A. C. Hornady and S. W. Brock, Jr., in a recent unpublished study of the stratigraphy of Cass and Sarpy counties, in Nebraska, have located a fault which crosses the Platte at a point just east of La Platte. Its upthrow is on the northwest. This fault, if extended, would cross the Missouri in the direction of Mosquito Creek or a short distance north or south of it. Therefore, if there is a fault east of La Platte, as there seems to be, and it crosses our traverse, it will account for a considerable part of elevation of strata northwestward in the Platte section of Nebraska and in the traverse between Folsom and Crescent, Iowa.

The strike of the formations is thought to be NE-SW across the northern part of our traverse, and the distance from the exposed Plattsmouth at Folsom to the nearest outcrop of the Westerville in Nebraska, at a point just west of La Platte, is about 6 miles, whereas the distance from La Platte (across the Platte Valley) to the exposure of the Plattsmouth in the bluffs NW of the City of Plattsmouth is two miles. The fault, noted above, probably extends in a NE-SW direction across this latter stretch.

Evidently, the formations between the Westerville and the Plattsmouth drop southeastward by dip and fault in the two-mile covered-stretch between La Platte and the bluffs south-

east therefrom. This covered zone of dip and fault probably reaches northeastward past north of Folsom, and unless it widens in Iowa, the major part of the deformation should cross the traverse between 3 miles north and 5 or 6 miles north of Folsom, beyond which, if this condition obtains, the strata lift slowly towards Crescent.

There remains the task of determining the exact position and attitude of the formations in the traverse north of Folsom. This problem should be investigated by core drilling at well selected locations.

History of Classification:—The classification of the Pennsylvanian beds that outcrop in this traverse has been accomplished rather slowly, due to structural conditions and the thick mantle of Pleistocene deposits. The strata of this area are isolated from their exposures in eastern Kansas and northwestern Missouri by the Forest City basin and the Brownville syncline, through which they extend beneath younger formations.

Dr. White (1) and Dr. Udden (3-4) measured and described the geologic subdivisions exposed here but did not classify them. Broadhead [9] sectioned the Pennsylvanian of Missouri rather closely. He and others named the leading formations of that state. About the same time, geologists ran several traverses and named and described many formations and members in Kansas.[10] Investigation, carried on separately in Missouri and Kansas, resulted in the duplication of formations and names, and the correlation between these states has continued to date.

The study and classification of the beds in the northern area (Nebraska and Iowa) continued for a time independently of what had been accomplished in Kansas and Missouri because it was difficult to correlate with those states. Keyes [11] grouped the strata in the southern part of our traverse, as Plattsmouth limestone, Platte shale, Forbes limestone and the basal part of the Atchison shale. The name Plattsmouth

[9] Broadhead, G. C., Geol. Surv. of Missouri, 1872.
[10] Contributions by Swallow, Haworth, Bennett, Kirk, Beede and others in Vol. I and later reports of the Kansas Geol. Surv.
[11] Keyes, C. R., Vol. 7, Proc. Ia. Acad. Sci.

had been used by Meek & Hayden [12] and the terms Forbes and Atchison had been used by Broadhead in Missouri, the latter for younger beds than those exposed in our traverse. Todd (2) and Smith (5) at first recognized the terminology and subdivisions of Keyes and later those of the Missouri Survey. Condra & Bengtson (6) followed Smith and others but made errors in the classification of the Platte Valley section. Both Smith [13] (1916) and Tilton (7) (1920) applied the Missouri and Nebraska correlation to Iowa, which has lead to some confusion.

During the early geological investigation in the northern Mid-Continent region, formations were defined rather loosely. For example, the Oread limestone was defined in 1894 to include four limestone units and three shale units. Prior to this, Meek & Hayden used the name Plattsmouth limestone for the main limestones exposed at Plattsmouth. Following the year 1894, geologists used the term Plattsmouth and Oread more or less interchangeably and without definite application until the members of the Oread were defined. Similarly, confusion arose in regard to the "Forbes" limestone i.e., the Deer Creek. The name Forbes was applied by Broadhead in 1872 to what is now essentially the Ervine Creek limestone and the name Deer Creek was applied in 1896 for the whole of a formation in Kansas.

It was the opinion of the senior author, at the time he defined the members of the Deer Creek, that the name "Forbes" should be used for the main member of the Deer Creek formation. Correspondence with the U. S. Geological Survey brought the decision that the name "Forbes" should be discontinued because of its conflict with the name Deer Creek which had gained general use and acceptance.

In 1927, Condra (8), having correlated the Nebraska sections with Kansas and Missouri, classified the Pennsylvanian of Nebraska, and applied the nomenclature to the sections in the area covered in this paper, but he was in doubt regarding the correctness of certain correlations in the Platte Valley

[12] Meek & Hayden, U. S. Geol. Surv., Nebraska and Portions of the Adjacent Territories, 1872.
[13] Smith, Geo. L., Proc. Ia. Acad. Sci., Vol. 5, 1916.

area. Next, the Platte section was re-studied and the lower strata there were found to be older than had been supposed, i.e., in the lower part of the Missouri Series. This section was then correlated with the Kansas City section and published in 1930,[14] when such names as "Cullom limestone" and "Cedar Creek limestone" were abandoned. At that time the names Beil limestone and Sheldon limestone were applied to the members which had been wrongly correlated as "Cullom" and "Cedar Creek," and the names Kenosha shale, Ost limestone and Rakes Creek shale were applied to the subdivisions of the Tecumseh shale. However, since the Platte section was re-correlated, Moore and his co-workers have re-classified the Kansas City section, which has made it necessary to further correlate the Platte Valley traverse.

Dr. Raymond C. Moore has sub-divided the Howard and Kanwaka as members. In ascending order, the members of the Howard are the Church limestone, Winzeler shale and Utopia limestone and those of the Kanwaka are the Jackson Park shale, Clay Creek limestone and Stull shale. The members of the Howard persist to southeastern Nebraska (DuBois) and northwestern Missouri (Forest City) beyond which the formation is represented by the Church limestone. The Kanwaka formation thins rapidly from Kansas to Iowa and its members have not been differentiated in the northern sections.

The classification employed in this paper recognizes the changes in correlation and nomenclature that have been made the past few years.

CONCLUSIONS:

1. The strata exposed in this traverse are older than those outcropping just south and southeast of the Jones Point Deformation, due to their up-folding in the anticline and probably due in part to faulting with the up-throw on the north.
2. The structural attitude of the strata in this traverse is about the same as it is along the Missouri in Nebraska.
3. The Bartlett syncline seems to have been overlooked by

[14] Condra, G. E., Bull. 3, Second Series, Nebr. Geol. Surv., 1930.

White, Udden, Smith and Tilton.

4. North of the Bartlett syncline the strata lift quite rapidly in the Haynies section, beyond which they lie nearly flat with a slight rise northwestward to Folsom, where they probably lift more rapidly against the Nehawka-Richfield anticline to Crescent, unless this latter elevation in due in part to faulting.
5. The correlation of the exposed strata in this traverse has been made with considerable certainty northward to Folsom, beyond which it will require subsurface study to more definitely establish the age and correlation of the natural subdivisions.
6. This investigation is part of a cooperative regional stratigraphic and geographic study planned to determine and establish the exact occurrence of geologic units to serve as a basis for future study in lithology, paleontology and economic geology, irrespective of state boundaries.
7. The geologic units exposed in the southern sections of this traverse are remarkably uniform in thickness and are widely persistent. The accompanying table supports this conclusion.

TABLE SHOWING THE THICKNESS (IN FEET) OF CERTAIN FORMATIONS AND MEMBERS IN NORTHEASTERN KANSAS, NORTHWESTERN MISSOURI, SOUTHEASTERN NEBRASKA AND SOUTHWESTERN IOWA

Formation	Member	Kansas Valley Topeka to Lawrence, Kans.	Missouri Valley Iowa Point to Atchison	Missouri Valley Forest City to Amazonia, Mo.	Big Nemaha Valley DuBois and in deep wells of Richardson County, Nebraska	Weeping Water Valley Wabash to Nehawka, Nebr.	Missouri Valley East of Union to Plattsmouth, Nebraska	Missouri Valley From 3 mi. north of Thurman to Folsom, Iowa
	Howard Limestone	7	About 6	6+	8½	4+	7	4½
	Severy Shale	24+	26	27	21	10+	10	10+
Topeka	Coal Creek Ls.	4–6	5	4–5	5	4+	5	5
	Holt Shale	3	1 5/6	2	2¼	1 5/6	1⅚	2 1/10
	DuBois Ls.	½–3	1⅓	1⅓	2 5/6	½	¾–1	¾
	Turner Ck. Sh.	3⅓	4½+	4½	2¾	5	6	6⅙
	Curzen Ls.	12–20	8+	6	6+			
	Calhoun Shale	45	24	10½	9 *			
Deer Creek	Sheldon Ls.	0–2	2½	2–3	5 *	3–4	3½	3½–4
	Jones Pt. Sh.	6+	9–11	10	9 *	7	8½	6½–7
	Ervine Ck. Ls.	16+	15+	16	16 *	24–25	24	24⅓
	Mission Ck. Sh.	3–4	5	3–4	1½ *	1 1/6	1–1½	1½
	Plummer Ls.	1⅔	2	1⅔	5½ *	1+	1	¾
	Larsh Shale	5–7	7	6–7	9 *	1½–2	1⅙+	2
	Rock Bluff Ls.	5	5	5+	2 *	2	1½–2	1¾
Tecumseh	Rakes Creek Sh.	45–50 (Not Differentiated)	50 (Not Differentiated)	50+ (Not Differentiated)	50 (Not Differentiated) *	24–25	17	16½
	Ost Limestone					2	1½	4
	Kenosha Shale					6–7	6½	7
Lecompton	Avoca Ls.	5	1½–2	1–2	4 *	2+	2½	2
	King Hill Sh.	6+	6+	4+	2 *	7½	7–8	7
	Beil Limestone	7–12	5+	5+	7 *	6–7	5	4–5
	Queen Hill Sh.	3–4	5–6	4½	4 *	5½	5–6	5½
	Big Springs Ls.	3¼	2½–3	2	9 *	⅔–1+	½–1	1
	Doniphan Sh.	4–8	8	7–8	4 *	5–6	7	6
	Spring Br. Ls.	6½	4½–6	4–6	6 *			
	Kanwaka Shale	70+	31+	31	19 *			
Oread	Kereford Ls.	5–8	4–10	5–12	5 *			
	Heumader Sh.	2–3	5	2¾	4⅓ *			
	Plattsmouth Ls.	17	20–21	21	29⅔ *	26½	27	21 exposed
	Heebner Shale	5½	5	5	4 *	5–6	5+	x
	Leavenworth Ls.	1 5/6–2	2	2	2 *	1⅓	1½–1 5/6	x
	Snyderville Sh.	12–12½	11–12	14	15 *	11–12	13–14	x
	Weepingwater Ls.	9–10	5–8	4½–7	5 *	5–6	7–8	x

x Not exposed.
* Well records, Richardson County, Nebraska.